

What is claimed is:

- 1 1. An apparatus to manufacture dental aligners, comprising:
2 a workpiece introduction system, including at least one workpiece preparation chamber;
3 and
4 a mold manipulation system, including:
5 a mold introduction chamber, wherein a series of different molds may be
6 introduced one after the other;
7 a mold preparation chamber;
8 a workpiece operation chamber; and
9 a mold manipulator to move the mold between the mold introduction chamber,
10 the mold preparation chamber, and the workpiece operation chamber; and
11 a workpiece manipulator to move the workpiece between the workpiece preparation
12 chamber and the workpiece operation chamber.
- 1 2. The apparatus of claim 1, wherein the workpiece introduction system is an inline system.
- 1 3. The apparatus of claim 1, wherein the workpiece introduction system is a rotary turret system.
- 1 4. The apparatus of claim 1, wherein the mold manipulation system is a rotary turret system.
- 1 5. The apparatus of claim 1, wherein the mold introduction chamber and the mold preparation
2 chamber are the same chamber.
- 1 6. The apparatus of claim 1, further comprising a clamp system to connect the workpiece to the
2 workpiece manipulator.
- 1 7. The apparatus of claim 1, further comprising a cutter, whereby an individual workpiece may
2 be removed from a roll of plastic.

- 1 8. The apparatus of claim 1, wherein the workpiece preparation chamber includes an oven.
- 1 9. The apparatus of claim 8, wherein the oven includes a preheater or a heater or both.
- 1 10. The apparatus of claim 1, wherein the mold preparation chamber includes an oven.
- 1 11. The apparatus of claim 10, wherein the oven includes a preheater or a heater or both.
- 1 12. The apparatus of claim 1, wherein the mold manipulation system further comprises a plug
2 manipulator to move a plug into the workpiece operation chamber.
- 1 13. The apparatus of claim 1, further comprising a laser-marking system to mark the workpiece
2 following its removal from the workpiece operation chamber.
- 1 14. The apparatus of claim 1, further comprising a trimming system to trim the workpiece
2 following its removal from the workpiece operation chamber.
- 1 15. The apparatus of claim 14, wherein the trimming system includes a multiple-axis CNC
2 system.
- 1 16. The apparatus of claim 15, wherein the trimming system includes a 5-axis CNC system.
- 1 17. A method of manufacturing a series of dental aligners, comprising:
2 inserting a first workpiece into a workpiece preparation chamber;
3 preparing the first workpiece for processing by subjecting the first workpiece to at least
4 one preparation process;
5 moving the first workpiece into a workpiece operation chamber;
6 moving a first mold into a mold preparation chamber;
7 preparing the first mold for processing by subjecting the first mold to at least one
8 preparation process;
9 moving the first mold into the workpiece operation chamber;

10 moving the first mold and the first workpiece into cooperative engagement;
11 subjecting the first workpiece to a vacuum on the side of the first workpiece facing the
12 first mold; and
13 repeating the above steps for a second workpiece and a second different mold.

1 18. The method of claim 17, wherein the preparing the first or second workpiece includes
2 heating the first or second workpiece, respectively.

1 19. The method of claim 17, wherein the preparing the first or second workpiece includes pre-
2 heating the first or second workpiece, respectively.

1 20. The method of claim 17, wherein the preparing the first or second mold includes heating the
2 first or second mold, respectively.

1 21. The method of claim 17, wherein the preparing the first or second mold includes pre-heating
2 the first or second mold, respectively.

1 22. The method of claim 17, further comprising moving a plug and the first workpiece into
2 cooperative engagement.

1 23. The method of claim 17, further comprising marking the workpiece.

1 24. The method of claim 23, wherein the marking is performed by a laser-marking device.

1 25. The method of claim 17, further comprising trimming the workpiece.

1 26. The method of claim 25, wherein the trimming is performed by a CNC device.

1 27. The method of claim 20, wherein the heating occurs at a temperature of between about 525
2 and 595°F.

- 1 28. An apparatus for fabricating a mass-customized appliance, comprising:
2 a web feeder;
3 a load station coupled to the web feeder to receive a mold; and
4 a forming station coupled to the load station to generate the appliance.
- 1 29. The apparatus of claim 28, further comprising a programmable logic controller (PLC) to
2 control the forming station.
- 1 30. The apparatus of claim 28, wherein the PLC controls electrical and pneumatic I/O for the
2 web feeder, heat zone, rotary SLA feed, forming, machine vision and die cutting functions.
- 1 31. The apparatus of claim 28, wherein the PLC stores and retrieves multiple recipes.
- 1 32. The apparatus of claim 28, wherein the PLC communicates over a network to allow real
2 time monitoring of production throughput, preventive maintenance, and remote diagnostics
3 management.
- 1 33. The apparatus of claim 28, wherein the web feeder provides an in and out-feed to a piercing
2 chain to provide safe rapid recovery from both machine malfunctions and roll change out.
- 1 34. The apparatus of claim 28, further comprising a heater to provide a heat zone over the web
2 feeder.
- 1 35. The apparatus of claim 34, wherein the heat zone further comprises a plurality of in-line
2 individually controlled modular ceramic heaters.
- 1 36. The apparatus of claim 28, wherein the load station comprises an opposing dual platform to
2 allow continuous rotary introduction of unique molds to web without interruption to the process.
- 1 37. The apparatus of claim 28, wherein the load station allows simultaneous loading of the next
2 mold during the forming process.

- 1 38. The apparatus of claim 28, wherein the forming station allows continuous introduction and
2 removal of new unique mold to be thermoformed at each cycle.
- 1 39. The apparatus of claim 28, wherein the forming station further comprises a pressure /
2 vacuum chamber and wherein the pressure/vacuum chamber is first sealed on the web to allow
3 pre-forming.
- 1 40. The apparatus of claim 28, wherein the mold is introduced to the pre-formed web and
2 simultaneously the vacuum and pressure are applied to form the material on the mold.
- 1 41. The apparatus of claim 28, wherein the material is blown in a first direction over the mold
2 and then blown in an opposite direction to deposit over the mold.
- 1 42. The apparatus of claim 28, wherein each is built with a 2D data matrix code containing
2 unique identification.
- 1 43. The apparatus of claim 28, further comprising a machine vision module that performs data
2 acquisition from a multi-dimensional matrix code and reports the acquired data to a laser
3 marking system.
- 1 44. The apparatus of claim 43, wherein the vision module comprises a camera and a light ring set
2 up vertically over the station.
- 1 45. The apparatus of claim 43, wherein when the chamber is opened the load platform is
2 withdrawn and the mold is retained in the web and transferred to the machine vision module.
- 1 46. The apparatus of claim 28, further comprising a laser marker.
- 1 47. The apparatus of claim 46, wherein the laser marker is a diode pump laser with marking
2 head, standard marking and targeting software and laser parameters.

- 1 48. The apparatus of claim 43, further comprising an interface to receive machine vision data
- 2 acquisition and software for matching data file.